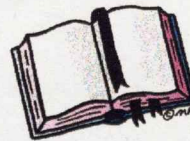


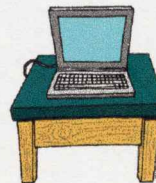


RESEARCH DAYS



**REPORT ON
THE DEPARTMENT OF MECHANICAL AND
INDUSTRIAL ENGINEERING
2003-2004 RESEARCH DAYS**

**Prepared by
Sophie Mérineau**



MAY 2004

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Introduction of the Research Days

This past year the Department of Mechanical and Industrial Engineering organized for the first time a series of seminars on the research activities of our Faculty Members. The organizers of the RESEARCH DAYS were Dr. Chun Yi Su and Dr. Javad Dargahi with the assistance of Sophie Mérineau.

Purpose

The purpose of the Research Days is to provide an opportunity for members (faculty, staff and students) of the Department to have some idea about the research activities carried out in the Department, to enhance collaboration between researchers, and also to instill interest in students to take up research projects with professors in the Department. The Research Day was held each month, except in December, in the conference room of the Department of Mechanical and Industrial Engineering before the Department Council Meeting. The first one started in November 2003 and it was such a success that the conference room was overflowing with attendees. The last Research Day was held in April 2004.

Successful Event

Each seminar was well attended by graduate and undergraduate students and Faculty members. This event was so successful that the organizers are planning to hold the Research Days again next year and they are thinking of inviting external guest speakers. We think that the students and members of the Department really enjoyed those seminars because it gave them the opportunity to ask questions to our Faculty members to better understand the different research areas available in our Department. This report includes all the abstracts of the presentations that were held in 2003-2004.



Abstracts of the presentations held on November 14, 2003

by Suong V. Hoa, Marius Paraschivoiu, Ion Stiharu, Chun-Yi Su, Kamran Siddiqui and Luis Rodrigues

Research in Materials and Composites

Suong V. Hoa

Concordia Center for Composites
Department of Mechanical and Industrial Engineering
Concordia University

My research focuses mainly on the Development, Design and Manufacturing of Composite Materials and Structures. The research can be grouped into four areas:

1. Long fiber thermoplastic composites:

Projects in this area deal with the development of new products using thermoplastic composites. These include wing box panels for Bombardier aircraft structures, Cross piece for Bell helicopter landing gear, and composite rod for the reinforcement of concrete. In order to develop these products, knowledge needs to be developed for the understanding of the behavior of the materials, the manufacturing process and the design of structures using these materials.

2. Polymer Nanocomposites:

Projects in this area deal with the enhancement of properties of polymeric resins by the addition of nanoclay particles. The properties enhancement include improvement in flammability resistance, moisture absorption resistance, and enhancement in physical and mechanical properties.

3. Mechanics of composites:

Projects in this area deal with the use of mechanics to understand the behavior of structures made of composite materials. Current projects include the characterization of mechanical behavior of triax composite structures for satellite applications.

4. Shrinkage of resins:

Projects in this area come about due to the development of a new instrumentation for the continuous monitoring of history of shrinkage of thermoset resin. Effects of compositions of the resin on its shrinkage are examined. Resin shrinkage in turn has effect on surface finish, residual stresses in composite parts etc.

Bounds for the Output of the Steady Incompressible Navier-Stokes Equations

Marius Paraschivoiu

Department of Mechanical and Industrial Engineering
Concordia University

A design engineer is often interested in optimizing a system based on some specific characteristic values of that system. For fluid mechanics or heat/mass transfer problems, these characteristic values, namely 'outputs', may be the temperature at some location, or the flow rate of the underlying system, and can be expressed as linear functionals of the system's field variables, which are temperature, density, and velocities. For simulation based engineering design, the relevant system may be modeled by partial differential equations (PDEs) which yield field variable solutions. The accuracy of numerical solution of the PDEs depends of the discretization size and may required large computational resources. This presentation describes a finite method that provides bounds to the output of the numerical solutions to the three dimensional Navier-Stokes equations at a fraction of the cost of calculating the output directly.

Fundamental and Applied Research in Microsystems - MEMS

Ion Stiharu
CONCAVE

Department of Mechanical and Industrial Engineering
Concordia University

A number of ongoing projects will be presented and discussed mostly from the challenges that face point of view. Specific accomplishments of the projects will be also pointed out.

Research on Control Systems with Hysteresis Nonlinearities

Chun-Yi Su

Department of Mechanical and Industrial Engineering
Concordia University

Hysteresis nonlinearities are very common in industrial control systems. For decades, the existence of such nonlinearities have provided one of the most difficult challenges to control design engineers since the entire Laplace domain and most state space control design techniques were developed exclusively for differentiable linear or nonlinear systems. Hence, the existence of hysteresis nonlinearities in actuators and systems were neglected and the controllers were designed based on the nominal smooth systems. When the systems are considered with non-differentiable nonlinearities, these methods encountered substantial difficulties in the analysis, model fitting and control design stages. It was extremely difficult, if not impossible, to design or prove stability of such systems. The development of techniques for the identification of such nonlinearities in realistic industrial plants has emerged as a significant problem in itself.

This presentation is intended to raise awareness of modeling and control techniques and to provide an opportunity to discuss state-of-the-art solutions for the problems. The presentation and discussion will range from modeling of hysteresis, to the design of corresponding control schemes, especially in the absence of complete information concerning the system model and state. The presentation is designed to appeal to an audience from different backgrounds. People working in the area of control will have a chance to interchange ideas and to view problems from different perspectives. People working in other areas will also benefit by understanding the new methods and technologies developed from control's point of view.

Experimental Techniques and the Investigation of Heat and Mass Transport

Kamran Siddiqui

Department of Mechanical and Industrial Engineering
Concordia University

Particle image velocimetry (PIV) and infrared (thermal) imagery are two state-of-the-art optical techniques to measure velocity and temperature fields, respectively. PIV is a non-intrusive technique, which measures velocity vectors in a plane simultaneously at many (typically more than a thousand) points in a flow field. This technique can measure flow velocities over a very wide range of flow scales typically from few centimeters to few microns. Infrared imagery is also a non-intrusive technique to measure surface temperatures with high spatial resolution.

The rates at which heat and mass are transported across fluid-fluid interfaces, and at which heat is transported across solid-fluid interfaces, is critically important to many natural and industrial processes. We are investigating of the physical mechanism(s) that control the interface heat and mass transfer. The controlled flux technique (CFT) has been used to remotely measure the local air-water heat transfer velocity using infrared imagery. However, for most of the real world applications, the accuracy of the technique is very low. We are working on to improve the accuracy of this technique and to implement it to a wide range of applications.

A vortex or coherent structure is a characteristic feature of a wide range of shear flows, with its scale varies from a few microns to hundreds of meters. It is also responsible for the large-scale transport of heat, mass and momentum. Experimental investigation of the flow characteristics inside concentric vortices revealed that they are self-similar in nature. We are developing a generalized model that can accurately predict the flow characteristics and the pressure field inside a vortex.

Thermoacoustics refrigerator is a device that converts sound energy to heat energy. These devices have many advantages as compared to the conventional refrigerators. For example, no environmentally hazardous refrigerants are required and their design is very simple. However, the efficiencies of thermoacoustic refrigerators are lower than their conventional counterparts. We are currently in a process of developing a low-power thermoacoustic refrigerator.

The above-mentioned topics will be presented and discussed in detail in the seminar.

Computer Aided Controller Design with Applications to Vehicle Dynamics

Luis Rodrigues

CIC

Department of Mechanical and Industrial Engineering
Concordia University

Increasing demands on performance for complex engineering applications over wide operating regimes have caused control designers to move from a single controller to multi-mode controllers incorporating both event-driven logic and a continuous or discrete time-driven state. Such is the case of mode switching controllers. However, traditional control methodologies were developed for single controller design for systems with either a time-driven state or an event-driven state, but not both. This limitation motivates research on mode switching controller design methodologies and its implementation in industrial systems. For such implementation, techniques based on computational technologies become essential in reducing design time and improving performance. Based on these considerations, this presentation will focus on the development of a computer aided controller design tool for systems exhibiting nonlinear dynamical phenomena. Applications will focus on vehicle dynamics.

Abstracts of the presentations held on January 9, 2004

by Rama B. Bhat, Akif Bulgak, Martin D. Pugh, Muthukumaran Packirisamy, Wenfang Xie and Yong Zeng

Dynamics of Machines and Mechanical Systems

Rama B. Bhat

Department of Mechanical and Industrial Engineering
Concordia University

The presentation will include results of studies on the dynamics of machines and mechanical systems carried out by R. Bhat and his graduate students and co-investigators. The studies are on:

1. Control of whirling vibrations in BTA deep hole boring process using fuzzy logic modeling and active suppression techniques. The whirling vibrations are measured using two proximity pickups placed in two orthogonal directions at a point along the boring bar. The characteristics of the machined surface such as the roughness, circularity, straightness etc. are also measured and related to the machining parameters using fuzzy logic.
2. Assessment of rumble strips between driving lanes and bicycle paths to ensure bicycle stability and safety. Tests are conducted on specially laid rumble strips by the Ministry of Transport Quebec, by the side of a High Way stretch. Two different types of bicycles are used in the tests and the tests are conducted at 3 different speeds using several test subjects.
3. Stability Analysis of twist Drills. The whirling behavior of twist drills when subjected to the unbalance in cutting loads are analyzed. Experiments will be carried out using proximity pickups.
4. Use of scaled models for dynamic testing of large structures.
5. Design and development of a thermoacoustic refrigerator.

Research in Manufacturing Systems and Quality

A.A. Bulgak

Department of Mechanical and Industrial Engineering
Concordia University

This presentation introduces examples of several research topics in Manufacturing Systems and Quality. The first part of the presentation covers issues on the design optimization of open assembly systems using artificial neural networks and heuristic search algorithms. Topologies of open assembly systems as well as the challenges in designing such systems for an optimal performance are discussed. New and innovative solution methodologies to the design optimization problem, in which simulation metamodels are used with the Artificial Neural Networks (ANNs), are presented. The use of Genetic Algorithms in conjunction with the ANN metamodels is introduced to finalize the design optimization problem.

In the second part of the presentation, we cover another current research area in the Six Sigma Design. Whereas Six Sigma methodology provides businesses with the tools to improve the capability of their business processes, this methodology also attracted many critics from the practitioners from industry. In view of these, to address these critics, we propose a new methodology of six sigma design through process optimization using Robust Method. Our initial findings are showing promising improvements in the sigma level of the process using the proposed methodology.

The third part of the presentation addresses to another manufacturing systems problem in solving large-scale capacitated cell formation problems with multiple routings. We present a comprehensive model for designing a cellular manufacturing system. The model bridges several known problems in that it integrates the cell formation problem, the machine allocation problem, and the part routing problem. We also discuss various solution alternatives to this highly complex comprehensive mathematical model.

The presentation is finalized by presenting few other research topics in the area of Industrial Engineering, such as Operations Research applications in airline industry and Hazardous Materials transportation risk assessment, without getting into the details.

Novel Engineering Materials

M.D. Pugh

Department of Mechanical and Industrial Engineering
Concordia University

The area of research includes several types of materials with the emphasis on microstructure – processing – property relationships i.e. what effect do various types of processing have on the microstructure and hence properties of engineering materials. One area of investigation is into the production of ceramic structures from the pyrolysis of natural, organic structures such as wood. These materials can act as filters etc or as precursors for composite materials. Another area of investigation is into metal-ceramic joining processes using transient liquid phase brazing. This is used to join iron aluminide intermetallics to silicon nitride ceramic. Composite materials based on nano-clay reinforced epoxies are being studied in collaboration with Dr Hoa. One more area of processing –property relationships is in the area of cryogenic heat treatment and its effect on the fatigue and impact performance of metal alloys.

Research on Microfabrication and Microsystems

Muthukumaran Packirisamy

CONCAVE

Department of Mechanical and Industrial Engineering
Concordia University

The presentation will cover the present research activities such as XeF₂ and TMAH Micromachining techniques, novel way of characterizing the micromachining characteristics, development of MEMS device for space application, development of MEMS devices for automobile applications, modeling of Microsystems, characterization of AFM probes, dynamics of microstructures and optical MEMS. The presentation will also include other possible microfabrication areas under the new proposed facility, ConSiM.

High Precision Control of Imperfect Actuators under a Wide Temperature Range

Wenfang Xie

Department of Mechanical and Industrial Engineering
Concordia University

Actuators are the important components to put mechanical systems into action in the control system loops. The imperfect actuators severely affect the performance of the control systems. The imperfections can be caused by the nonlinearities such as backlash, hysteresis, friction and saturations, the uncertainties such as parameter variation and modeling error and the dynamic constraints such as system bandwidth and mechanical response.

However, even for a certain environment range, it is very difficult to assure high position accuracy due to the imperfections, let alone for a wide range. For example, the large temperature change characteristics of on-orbit operations gives a drastic variation to the joint actuators of the space robots leading to the significant changes of the structure and parameters of the actuators. In this case, it is difficult to deal with for a standard controller. To address the control demands of such highly complex and uncertain systems one can improve the precision control performance using soft computing technologies.

The objective of the research is to find reliable and practical control solutions that enable imperfect actuators to achieve high speed and position accuracy over a wide environment range. The ultimate goal is to develop smart control units to render the imperfect actuators high-end actuators without costly manufacturing. The proposed research will find tremendous applications in aerospace, manufacturing, and robotics industries where the imperfect actuators are used and environment changes drastically.

Computer-Aided Product Design and Realization

Yong Zeng

Concordia Institute for Information Systems Engineering
Concordia University

My research has been focused on computer-aided product development, including:

1. *Design Science*

This research aims at developing a formal design science for studying design activities in order to support substantially and enhance significantly the complex product design. The foundation of this research is the logic of design, which captures the fundamental nature of interdependence between design problem and design solutions. The central theme of this research is the reasoning capability of the design theory, which allows the derivation of theorems about design activities from axioms. The industrial applications of this research include the development of robust design methodology and computer-aided design systems.

2. *Computer-Aided Conceptual Design*

This research aims at developing theories and software systems to assist product conceptual design process. Research topics include design process modeling, requirements engineering, sketch representation and interpretation, design cognition, as well as design knowledge acquisition and representation.

3. *Geometric Modeling for Product Development*

This research aims at processing geometric information appearing in the product design and realization process. Research topics include subdivision and surface reconstruction. Applications include rapid prototyping of objects with complex surfaces.

Abstracts of the presentations held on February 13, 2004

*by Hugh McQueen, Kudret Demirli, Ali Akgunduz, Mingyuan Chen,
Brandon Gordon and Mamoun Medraj*

Hot Workability of Aluminum Alloys 1963-2003

H.J. McQueen, Department of Mechanical and Industrial Engineering, Concordia University

- Understand, optimize, improve extrusion, rolling, forging (80% of metal products)
- Deform at temperature $T=200-600^{\circ}\text{C}$ ($0.5-0.94T_M, K$), strain rate $\dot{\epsilon} = 10^{-2}-10^2 \text{ s}^{-1}$ to strain $\epsilon \approx 6$ by in-furnace torsion (no instabilities up to $\epsilon=60$)
- Determine influence of T , $\dot{\epsilon}$, ϵ on flow stress, ductility, **microstructure, mechanisms**, product properties
- Constitutive equations for modeling to estimate forces, safe forming limits and product properties
- Examine quenched-in **microstructures**: polarized optical for grains and subgrains TEM, SEM, OIM for **dislocation substructures**
- Establish mechanisms: **dislocation glide & climb, dynamic recovery DRV** grain boundary sliding, dynamic recrystallization DRX.....**NANOCRYSTALLINE**
- Target industrial alloys to see effects of: solutes (Al-Mg, 5000 series), **precipitates** (Al-Li, Al-Cu-Mg 2000 series, Al-Mg₂Si 6000, Al-Zn-Mg-Cu 7000,) stable dispersoid particles Al-Fe-Co conductors, Al-Mn-Mg can stock Al Matrix Composites
- Modeling by FEM of extrusion, drop in pressure vs stroke due to adiabatic heating, deformation zone distributions of T , $\dot{\epsilon}$, ϵ ; estimation of cracking and **substructure**
- Simulation of multistage rolling schedules with declining temperature; flow curves **substructure** for each stage, softening between stages by static recrystallization

Microstructures and Mechanisms

- Understand **evolution of microstructure** to conceive of a model or **mechanism**
- Strain occurs by **thermally activated dislocation motion; glide, cross glide, climb**
- Diminished monotonic strain hardening to **steady state regime**: T , $\dot{\epsilon}$, σ constant independent of ϵ due to **DRV** (as in secondary creep)
- **Dynamic recovery (DRV)** resulting from **dislocation annihilation, rearrangement into low energy, polygonized arrays** (subgrain boundaries SGB)
- **Subgrain size, SGB (boundary) and internal dislocation densities independent of ϵ (steady state)** characteristic of T - $\dot{\epsilon}$ or of σ
- **Subgrains remain equiaxed in elongating grains** that thin down to subgrain size
- Grain boundaries **GB become serrated by interacting with SGB**

- In thin grains, **serrations** on neighboring GB **meet** pinching-off grains into short segments this is **geometric DRX** (a pseudo recrystallization)
- High DRV providing easy flow in grain corners relaxes stress concentrations due to differential sliding at GB triple junctions thus preventing intergranular cracking

The Original Nanocrystalline Technology

- **Dislocation line core: 3-4 nm** actions: glide, cross glide, climb, annihilate, combine
- **Vacancies..... 0.5 nm** migration, sinks or sources at dislocations or at GB
-
- Coordinate the generation and interaction of above crystal imperfections ...DRV
- **Polygonized arrays of dislocations form subgrains that:**
 - 1) determine high T flow stress and ductility
 - 2) control product mechanical properties
- Do this by applying selected temperature T, strain rate $\dot{\epsilon}$ (as calibrated by microscopy)
- Perform this industrially on 500kg billet in an extrusion press (up to 40 MN) production about 160,000 tons / year
- On exit, quench and then age to produce **150 X 10 nm coherent particles for precipitation hardening**

Challenge, Competence, Controversy, Passion

1. **Subgrains** forming in original grains by **dislocation DRV (dynamic recovery)** <<versus>> new grain formation by discontinuous DRX (dynamic recrystallization).
2. **SGB continually rearrange** to maintain **equiaxed subgrains** with constant wall dislocation density <<versus>> continuous DRX.
3. **Subgrain formation in Al-5Mg** in steady state <<versus>> no subgrains at start of creep steady state.
4. DRX stimulated by strain concentrations at rigid particles (~2 μ m) in Al-Mg-Mn alloys <<versus>> none in Al-Mn.
5. **Billowing GB serrations (induced by SGB)** detach into islands in Al-5Mg <<versus>> discontinuous DRX.
6. In Al-5Mg large grain, tensile ultra ductility due to high $\dot{\epsilon}$ sensitivity from **Mg solute drag and DRV** <<versus>> GB sliding superplasticity (torsional ductility down and strength up by factor of 5 compared to Al).
7. Initial peaks in flow curves due to **dynamic precipitation** in Al-Mg-Si, Al-Cu-Mg and Al-Zn-Mg-Cu alloys <<versus>> solute hardening or DRX.
8. Transformation of **thin elongated grains with serrated GB** into **crystallites** (subgrains equaling grain thickness having several high angle facets) by **DRV geometric DRX** <<versus>> continuous DRX.
9. In hot working, **grain subdivision by transition boundaries of deformation bands (50 μ m) along with SGB (5 μ m spacing) from DRV** <<in contrast>> _____ to division by block walls (5 μ m) with cell walls (0.5 μ m spacing) in cold working.

Fuzzy Logic

K. Demirli

Department of Mechanical and Industrial Engineering
Concordia University

This presentation will start with the definitions of fuzzy sets, fuzzy logic and fuzzy models. Distinction between objective and subjective fuzzy models will be made. A simple fuzzy navigation model for mobile robots and a fuzzy model for modeling the surface finish in machining will be given as examples. Applications of fuzzy theory to modeling of sonar sensor data and performing localization for mobile robots will also be presented. Some current and future research directions will be identified.

Simulation and Optimization: i. Virtual Design and Manufacturing -- ii. Revenue Management in Airline Industry

Ali Akgunduz

Department of Mechanical and Industrial Engineering
Concordia University

Power of optimization and simulation brought two distinct areas of research work together under the same title in this presentation. In our research work we use simple optimization techniques to develop efficient methods to detect contacts between virtual objects that are simulated in real-time virtual reality simulations. We also investigate the application areas of optimization in revenue management practices in airline industry. Other areas that we investigate are; i. Developing a free-form sketching tool by using VR technology to be used in early stages of product design. ii. Developing algorithms that enable collision-free robot path planning. iii. Developing a fully automated virtual reality based naturalistic observation technique to assess customers within the concurrent engineering philosophy.

Manufacturing Systems Analysis - System Design and Operations Issues

M. Chen

Department of Mechanical and Industrial Engineering
Concordia University

Research problems related to manufacturing system design and operations control will be briefly discussed in this presentation. The complexity of some of the problems will be introduced along with possible solution approaches in industrial engineering to solve these problems.

Real-time Simulation of Mechanical Systems Using Distributed Computing Networks

Brandon W. Gordon
CIC

Department of Mechanical and Industrial Engineering
Concordia University

The recent emergence of high speed network technology has allowed clusters of computers to be linked together economically to form distributed computing networks capable of simulating systems that previously required expensive supercomputers. High speed network communication also allows the creation of virtual environments that allow many users to simultaneously interact with a distributed simulation. Distributed control systems linked by networks have also become common in many applications. The further expansion of the internet and rapid deployment of wireless network technology will no doubt result in even wider applications of distributed computing.

Despite the enormous potential of distributed computing there are currently few systematic approaches to guide the development of distributed real-time simulations of mechanical systems. A mechanical system simulation is generally characterized by complex interconnections of heterogeneous mechanical models that may involve different types of equations with different solution methods. The complexity and heterogeneous multi-domain nature of mechanical system models that arise in automotive, aerospace, and virtual reality applications make systematic decomposition into a distributed network a difficult unsolved problem. This presentation describes recent results from the Control and Information Systems (CIS) laboratory related to distributed real-time simulation of mechanical systems. The main problems to be addressed include real-time communication using Ethernet based networks, simulation of differential-algebraic systems, and virtual reality applications. Together these results lead towards a systematic framework for design and analysis of distributed real-time simulations of mechanical systems.

Understanding Materials through Computational Thermodynamics Combined with Experimental Investigation

M. Medraj

Department of Mechanical and Industrial Engineering
Concordia University

Research on Mg alloys is fueled nowadays by the need for low-density materials that suit aerospace and automobile industries. Knowledge of the phase equilibria of Mg-alloy systems is crucial for improving existing alloys and developing new ones. Besides, processing of materials depends strongly on accurate thermodynamic data of the material system. Development of thermodynamic database for such multicomponent alloys requires a combination of experiments and computational thermodynamics. Since numerous binary and ternary systems have to be treated before multicomponent alloys can be calculated, this development becomes a long-term project. In my research a thermodynamic database of several promising alloying elements will be established. This includes Al, Sr, Ca, Sb, Li, Si, Mn, Y, Zr in addition to the rare-earth elements. My research group focused, in the beginning, on constructing Mg-alloy phase diagrams which have strong potential for creep resistance applications. Two of such systems are Mg-Al-Sr and Mg-Al-Ca. Thermodynamic modeling of these two systems has been carried out and the current understanding is being investigated experimentally, in collaboration with CANMET-MTL, by Differential Scanning Calorimetry (DSC).

Also in my presentation I will be discussing other projects which are being performed by my research group and external collaborators. These projects include: "Laser Welding of Mg-Alloys" in collaboration with AMTC and "Permeability of Metal Foams" in collaboration with IMI-NRC.

Abstracts of the presentations held on March 12, 2004

by George Vatistas, Wahid Ghaly, Ibrahim Hassan and Paula Wood-Adams

The Formulation of a Unique Analogy Shared Among the Elementary Tubular Vortices

Georgios H. Vatistas

Department of Mechanical and Industrial Engineering
Concordia University

Vortices arise in many technological devices and naturally occurring phenomena. In industry these are either set in motion deliberately or emerge as a parasitic bi-product of fluid motion. Tubular swirling vortical arrangements are considered to be the building blocks of turbulent motion. Their life cycle consisting from vortex evolution and decay phases, as well as the energy exchange among them are deemed to be important in explaining the basic mechanism of turbulence.

The presentation will feature the enlargement of the steady-state family of algebraic vortex equations that were proposed by us over a decade ago. Besides the significance of the subject matter in science and technology, the undertaking of the task was galvanized by a remark made by Rossow from NASA Ames who wondered how the disingularized algebraic steady models could be modified in order to describe the vortex decay problem. In the process to broaden the steady case into the time dependent type we have formulated a general space-time analogy, and have uncovered some unique properties of elementary vortex flows.

Based on a dimensional analysis, we unify the steady and decaying vortex conservation equations via a new independent variable that fuses space and time. Upon formalization of the analogy, the basic premise is used to elaborate on some new features exhibited by simple vortex flows. Finally, the principle is employed to transform our previous steady-state family of vortices into time-dependent. In fact it is shown that given a steady vortex, the corresponding time-decaying version can be obtained without having to solve formally the governing equations but rather through a simple variable transformation. Conversely, if the mathematical form of a decaying vortex is known, then the steady state member can be derived. Analysis discloses that both families are the offspring of a decaying vortex, originally potential with singular radial and axial velocities. The self-similarity is validated using data from various experimental studies.

Simulation-Based Analysis and Design of Turbomachinery Blading

Wahid S. Ghaly

Department of Mechanical and Industrial Engineering
Concordia University

The aerodynamic shape design of compressor and turbine blades is a crucial part of any gas turbine engine design cycle. Such design is very challenging due to the flow complexity, the stringent performance requirements and the restrictive constraints. The blade design problem can be automated by formulating it as an optimization problem where the designer's experience is incorporated into the mathematical formulation of the optimization problem as an objective function and a set of constraints. Another approach is the inverse blade design, it is one where the required blade performance is specified and the blade shape that would accomplish such performance is sought.

This presentation will focus on inverse design and optimization methods that are robust, accurate, applicable to three-dimensional flows, and can be easily implemented into (or make use of) existing CFD flow simulation codes. The implementation of these methods, particularly the challenging problems will be addressed and some of the successes of the methods will be presented.

Multiple Two-Phase Discharge from a Stratified Region

I. Hassan

Department of Mechanical and Industrial Engineering
Concordia University

The research and development of experimental correlations and theoretical models of the onset of gas and liquid entrainments, and mass flow rates during discharge from a stratified, two-phase region through branches of finite diameter have gained great importance in recent literatures due to their relevance in several industrial applications; some of which include nuclear reactor safety during postulated loss-of-coolant accidents, and two-phase distribution systems, where a certain incoming stream is fed into a larger header, as found in a shell-and-tube heat exchanger. Knowledge of the flow phenomena involved, the mass flow rate, as well as the quality of all discharging streams is essential for the design and/or performance prediction of such systems. The current research work in this area will be presented and discussed in this seminar.

Polymer Science and Novel Polymeric Materials

Paula Wood-Adams

Department of Mechanical and Industrial Engineering
Concordia University

New developments in the technologies of polymerization and polymer-clay composite production have resulted in promising new polymeric materials. In order to take full advantage of these new materials it is necessary to understand all of the steps from synthesis or manufacturing of the material to the behavior of a product made from the material in its application. In this work, we build mathematical models for the various intermediate relationships between material production and final properties by using probability theory, thermodynamic theory and molecular theories of polymer dynamics. These models are validated experimentally in our laboratory at Concordia or at collaborators' facilities. The presentation will include examples of several current studies illustrating various aspects of our program.

Abstracts of the presentations held on April 16, 2004

by Nadia Bhuiyan, Javad Dargahi, Rajamohan Ganesan, Vojislav Latinovic and Ramin Sedaghati

Product Design and Development

Nadia Bhuiyan

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Product design and development can be defined as the process of undertaking all the activities and processing the information required to develop a concept for a product up to the product's market introduction. It is perhaps the most significant activity within a firm. New products can represent a major portion of a firm's profits, therefore rapid turnaround of innovative, high quality, low cost products is needed to survive in today's global market. My research focuses on the detailed investigation of product development in high-technology industries, with a focus on strategies, processes, tools, and techniques used for success. Research methodologies include analytical, simulation, and empirical modeling. I also focus on actual product development, whereby, in conjunction with industry, we develop innovative products related to biotechnology and medical devices.

Haptic Sensing and Feedback System for Minimally Invasive Surgery and Robotics

Javad Dargahi

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Currently, commercially available endoscopic graspers used in Minimally Invasive Surgery (MIS) do not have any built-in or integrated tactile sensors. This means that the surgeon does not have any tactile feedback to manipulate the tissue safely. Thus, in order to enable the surgeon to feel the tissue and sense the presence of ducts and blood vessels during the procedure, tactile sensors should be incorporated into the endoscopic graspers. In this presentation I will discuss design, fabrication and testing of some sensors which could be integrated with endoscopic grasper thereby, compensating for the loss of tactile perception. In addition, I will talk about teletaction in MIS. Furthermore I will present some of my other research work in the area of biomedical engineering.

High-performance Composite Materials and Structures

Rajamohan Ganesan

Department of Mechanical and Industrial Engineering
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Composite materials and structures that are used in Mechanical, Aerospace, Civil Infrastructure, and Transportation industries have to be designed and developed for high performance under adverse loading and service conditions, and for stringent high performance requirements. Specially designed structures that are tailored to the specific needs of the intended applications need to be designed, developed and analyzed. Composite structures used in helicopters, aerospace structures, telecommunication applications such as satellite dishes, truck tires, and automobile panels can be cited as examples. In this regard, new analysis and finite element procedures have to be also developed to address the complexities that arise in these structures. For this purpose, during the past 10 years considerable research activities have been devoted at the Concordia Centre for Composites. The activities that addressed the material characterization, stress and vibration analysis, and failure analysis including buckling, fracture and fatigue failures will be summarized in the presentation.

Boring Machine Real-Time Control Using Expert System Knowledge Based Control with Multiple Sensors and CLIPS Language Software

Vojislav Latinovic

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The first project deals with the machine tool control used for deep-hole machining operation. The initial idea is that the control of the process can be accomplished by use of rapidly spreading Expert Systems, particularly knowledge based approach developed by NASA's Johnson Space Center but kept unavailable for long time. By middle of nineties a deep-hole machining group at Concordia University, started developing the expert control of Deep-Hole Machining System (DHMS), because of limitations that the Adaptive Control imposes in this operation. While all major parts of the system, including the chip concentration sensor, performed well the system failed to perform satisfactory when integrated. The major steps were retrofitting machine hardware to be capable of the on-line control such as continuous change of cutting speed and feed rate, and sensing cutting fluid pressure and flow rate. The next objective was sensors fusion in order to resolve the conflicts during the rule firing.

A further project objective is design, prototyping and implementation of viscous damper to replace traditionally used Coulomb friction damper. This would, hopefully, solve problem of chatter suppression since new damper could be tuned-up to desired damping through the controller according to sensed signal from the accelerometer attached to the cutting head.

The second research project deals with design of similar components and assemblies to avoid time consuming re-analyzing for each set of functional requirements but rather applying the scale factors resulting from similarity to get desired product sizes.

Finally, the third project deals with the synthesis of new cycloidal gearsets that allow obtaining large speed reductions by using cycloidal gear trains in a planetary arrangement. The kinematic analysis of these trains is accomplished and further research into their load rating and torque variation is necessary in order to claim a breakthrough in application of this very attractive power transmission.

Smart Structures

Ramin Sedaghati

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Large space structures are subject to a variety of load conditions. The traditional space structures cannot change their response mechanisms and are thus unable to perform successfully when subjected to varying load conditions, which may be different than those considered in the design stage and therefore may lead to subsystems or components failure and potential instability. In this seminar some research activities conducted in this emerging area will be discussed. Moreover other research activities regarding Structural Design Optimization and Force Limited Vibration Testing will be briefly examined.



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